

WHAT IS CLAIMED IS:

1. A digital watermark embedding apparatus comprising:
  - an acquisition unit configured to acquire a topological invariant as digital watermark information, key information corresponding to the digital watermark information, and a target content in which the digital watermark information is to be embedded;
  - 10 a function generation unit configured to generate a topological function corresponding to the topological invariant;
  - 15 a randomizing-function generation unit configured to generate a randomizing function based on the key information, and compute a composite function by composition of the randomizing function and the topological function; and
  - 20 a function-embedding unit configured to embed the composite function in the target content.
2. The digital watermark embedding apparatus according to claim 1, wherein the topological function includes a mapping from a base space concerning positions in the target content to a target space concerning embedding amounts, the mapping being based on the topological invariant.
- 25 3. The digital watermark embedding apparatus according to claim 2, wherein:
  - the target content includes one of still image

data and moving picture data;

the base space is defined by pixel positions corresponding to the target content; and

5 the target space is included in a topological space corresponding to a set of assignments of values to pixels composing the target content.

10 4. The digital watermark embedding apparatus according to claim 1, wherein the function generation unit generates topological function values which express the topological function.

15 5. The digital watermark embedding apparatus according to claim 4, wherein the randomizing-function generation unit generates composite function values by applying the randomizing function to the topological function values, the composite function values expressing the composite function.

20 6. The digital watermark embedding apparatus according to claim 5, wherein each of the topological function values and the composite function values indicate embedding amounts corresponding to positions in the target content.

25 7. The digital watermark embedding apparatus according to claim 5, wherein the randomizing-function generation unit randomizes the topological function values using a block cipher based on the key information to generate the composite function values.

8. The digital watermark embedding apparatus

according to claim 5, wherein the function-embedding unit embeds the topological invariant by varying the target content based on the composite function values.

9. The digital watermark embedding apparatus  
5 according to claim 1, wherein the function generation unit generates the topological function corresponding to the topological invariant which includes a homotopy invariant.

10. A digital watermark detection apparatus  
comprising:

an acquisition unit configured to acquire a topological invariant as digital watermark information, key information corresponding to the digital watermark information, and a target content in which the digital  
15 watermark information is to be embedded;

a function detection unit configured to detect an embedded-function embedded in the target content;

an ordering-function generation unit configured to generate an ordering function based on the key information, and compute a composite function by  
20 composition of the ordering function and the embedded-function; and

25 a topological invariant computation unit configured to compute a topological invariant based on the composite function, the topological invariant serving as digital watermark information.

11. The digital watermark detection apparatus

according to claim 10, wherein the composite function includes a mapping from a base space concerning positions in the target content to a target space concerning embedding amounts, the mapping being based 5 on the topological invariant.

12. The digital watermark detection apparatus according to claim 11, wherein:

the target content includes one of still image data or moving picture data;

10 the base space is defined by pixel positions corresponding to the target content; and

the target space is included in a topological space corresponding to a set of assignments of values to pixels composing the target content.

15 13. The digital watermark detection apparatus according to claim 10, wherein the function detection unit detects embedded-function values which express the embedded-function.

20 14. The digital watermark detection apparatus according to claim 13, wherein the ordering-function generation unit generates composite function values by applying the ordering function to the embedded-function values, the composite function values expressing the composite function.

25 15. The digital watermark detection apparatus according to claim 14, wherein each of the embedded-function values and the composite function values

indicate embedding amounts corresponding to positions in the target content.

16. The digital watermark detection apparatus according to claim 14, wherein the order-function 5 generation unit orders the embedded-function values using a block cipher based on the key information to generate the composite function values.

17. The digital watermark detection apparatus according to claim 14, wherein:

10 the composite function includes a mapping from a base space concerning positions in the target content to a target space concerning embedding amounts, the mapping being based on the topological invariant, the composite function including a parameter which is 15 related to the topological invariant and determines the mapping; and

the topological invariant computation unit computes the topological invariant by acquiring the parameter based on the composite function values.

20 18. The digital watermark detection apparatus according to claim 10, wherein the topological invariant computation unit computes the topological invariant which includes a homotopy invariant.

25 19. A digital watermark embedding method comprising:

acquiring a topological invariant as digital watermark information, key information corresponding to

the digital watermark information, and a target content in which the digital watermark information is to be embedded;

5 generating a topological function corresponding to the topological invariant;

generating a randomizing function based on the key information;

10 computing a composite function by composition of the randomizing function and the topological function; and

embedding the composite function in the target content.

20. A digital watermark detection method comprising:

15 acquiring a topological invariant as digital watermark information, key information corresponding to the digital watermark information, and a target content in which the digital watermark information is to be embedded;

20 detecting an embedded-function embedded in the target content;

generating an ordering function based on the key information;

25 computing a composite function by composition of the ordering function and the embedded-function; and

computing a topological invariant based on the composite function, the topological invariant serving

as digital watermark information.

21. A program stored in a computer readable medium for enabling a computer to function as a digital watermark embedding apparatus, comprising:

5           means for instructing the computer to acquire a topological invariant as digital watermark information, key information corresponding to the digital watermark information, and a target content in which the digital watermark information is to be  
10           embedded,

          means for instructing the computer to generate a topological function corresponding to the topological invariant;

15           means for instructing the computer to generate a randomizing function based on the key information;

          means for instructing the computer to compute a composite function by composition of the randomizing function and the topological function; and

20           means for instructing the computer to embed the composite function in the target content.

22. A program stored in a computer readable medium for enabling a computer to function as a digital watermark detection apparatus, comprising:

25           means for instructing the computer to acquire a topological invariant as digital watermark information, key information corresponding to the digital watermark information, and a target content in

which the digital watermark information is to be embedded,

means for instructing the computer to detect an embedded-function embedded in the target content;

5 means for instructing the computer to generate an ordering function based on the key information;

means for instructing the computer to compute a composite function by composition of the ordering function and the embedded-function; and

10 means for instructing the computer to compute a topological invariant based on the composite function, the topological invariant serving as digital watermark information.